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New records of *Toninia* from China

Congcong Miao [#1], Meijie Sun [#1],
Xiao Zhang [1], Zhaojie Ren [2], Ling Hu [*3]

[1] *Key Laboratory of Plant Stress Research, College of Life Sciences, Shandong Normal University, Jinan, 250014, P. R. China*

[2] *Shandong Museum, Jinan, 250014, P. R. China*

[3] *Institute of Environment and Ecology, Shandong Normal University, Jinan, 250014, P. R. China*

[*] Correspondence to: *ccmjy123@163.com*

Abstract—Four *Toninia* taxa (*T. albilabra, T. poeltii*, *T. tristis* subsp. *Arizonica,* and *T. tristis* subsp. *fujikawae*) are reported for the first time from China. Descriptions with morphological and chemical characters and known distribution are given for each taxon. A key to the species of *Toninia* s.l. in China is also provided.

Keywords—lichen-forming fungi, *Lecanorales*, *Ramalinaceae*, taxonomy

Introduction

Toninia, widely distributed in drought and arid areas, is an important component of desert lichen communities (Timdal 1991, 2002). The current delimitation of the genus is based mainly on the features of the asci and paraphyses (Meijie & al. 2019) and molecular genetic characters (cf. Kistenich & al. 2018, Ekman 2001, Ekman & al. 2008). *Toninia* is characterized by a crustose to squamulose and epruinose to densely pruinose thallus; lecideine, epruinose to densely pruinose apothecia; dark brown to colourless hypothecium; usually colourless, grey, green, or brown epihymenium and exciple that changes colour in K and N; clavate, *Biatora*-type, 8-spored asci; and elliptical to spindle-shaped, colourless, 1–8-celled ascospores. *Toninia*

[#] Congcong Miao & Meijie Sun contributed equally to this work.

was previously placed in *Lecideaceae* (Massalongo 1852; Timdal 1991; Zahlbruckner 1890). With the advent of the molecular age, phylogenetic analysis of lichens is carried out in combination with their morphological and anatomical features; currently, *Toninia* is classified in *Ramalinaceae* (Timdal 2002; Ekman 2001).

In this paper we contribute to the knowledge of *Toninia* in China and add accurate data for the Lichen Flora of China project by reporting on four taxa new to the country: *T. albilabra*, *T. poeltii*, *T. tristis* subsp. *arizonica* and *T. tristis* subsp. *fujikawae*.

Materials & methods

The specimens studied are preserved in the Lichen Section of Botanical Herbarium, Shandong Normal University, Jinan, China (SDNU) and the Lichen Herbarium of the Kunming Institute of Botany, Kunming, China (KUN). The morphological and anatomical characters of the specimens were examined under a COIC XTL7045B2 stereomicroscope and an Olympus CX41 polarizing microscope. Thallus and medulla were tested with K (a 10% aqueous KOH solution), Cl (a solution of aqueous NaOCl), and I (Lugol's iodine) for identification. Lichen substances were identified using standardized thin layer chromatography (TLC) techniques with system C (Orange & al. 2010). Photographs were taken with Olympus SZX16 and BX61 microscope with a DP72 camera.

Taxonomy

Toninia albilabra (Dufour) H. Olivier, Bull. Géogr. Bot. 21: 196 (1911) Fig. 1

Thallus squamulose, indeterminate. Squamules ≤2(–4) mm diam., scattered or contiguous to irregularly imbricate, orbicular or sometimes slightly lobed, weakly concave to weakly convex. Upper side reddish brown, usually epruinose, shiny, with regular and usually deep fissures in the cortex, pores and pseudocyphellae absent. Margin partly to entirely white pruinose. Underside white to pale brown. Algal layer continuous. Lower cortex poorly developed or absent.

Apothecia ≤1.5(–2.5) mm diam., weakly concave to weakly convex, usually persistently (but narrowly) marginate, densely white pruinose or more rarely epruinose. Proper exciple reddish brown throughout or with an additional grey pigment near the rim, lacking crystals. Hypothecium medium brown in upper part, pale brown to colourless in lower part. Hymenium 60–70 µm high; epithecium grey, K+ violet, N+ violet, containing crystals of calcium oxalate. Spores broadly to narrowly fusiform, 1-septate, 13.5–22.5 × 3–4 µm.

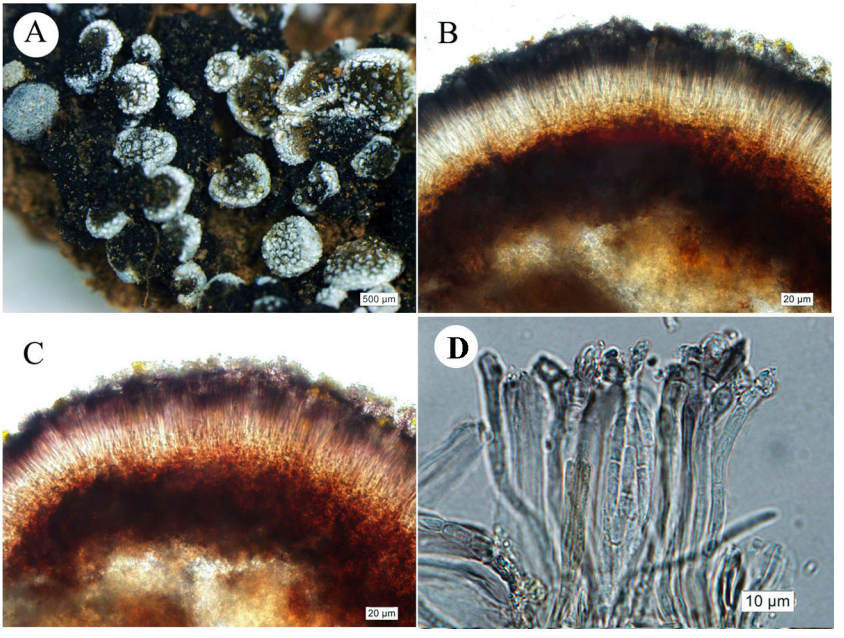

Fig. 1. *Toninia albilabra* (15-49721 KUN).
A. Thallus; B. Epihymenium; C. Purple K reaction of epihymenium; D. Ascospores.

Pycnidia not seen.

Chemistry—Terpenoids detected by TLC.

Specimens examined—**CHINA**. **Tibet**, **Baju County**, on the way from Bangda to Bangda Airport, alt. 4129 m, 17 Sep. 2014, Wang Lisong & al. 14-47025 (KUN); **Jiangda County**, Tongpu Township, 317 national highway side slope, 31°38′33″N 98°26′10″E, alt. 3940 m, 5 Oct. 2016, Wang Lisong & al. 16-51356 (KUN). **Yunnan**, **Zhongdian**, Benzilan Town, 28°10.47′N 99°23.01′E, alt. 2115 m, 27 Aug. 2006, Wang Li Song & al. 06-26674 (KUN); **Deqin**, Baima Snow Mountain, 28°19.47′N 99°05.13′E, 2 Nov. 2015, alt. 4350 m, Wang Lisong & al. 15-49721 (KUN).

Distribution—On rock or soil. *Toninia albilabra* has been reported in Europe, North Africa, Macaronesia, and the Middle East (Timdal 1991). New to China.

Comments—The Chinese material closely matches the previously published description by Timdal (1991). *Toninia albilabra* is morphologically similar to *T. sedifolia*, which differs mainly by having a smooth upper cortex, a thinner epinecral layer, and farinose pruina. The white edge of the squamules in

T. sedifolia is caused by pruina on the cortex surface and is not sharply delimited from the less pruinose inner part of the upper side. The white edge in *T. albilabra*, however, is caused by the white medulla being visible outside the sharply delimited, usually entirely epruinose, upper cortex (Timdal 1991).

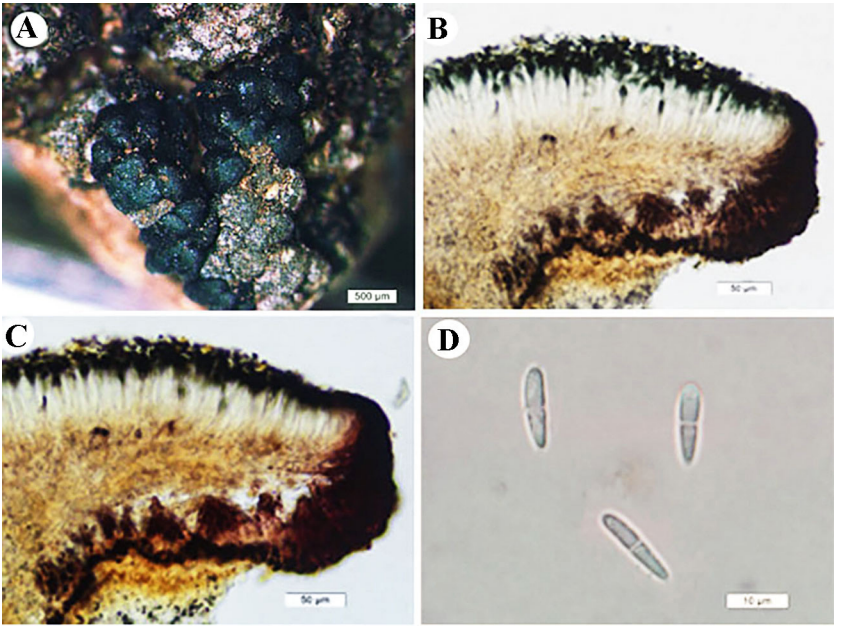

Fig. 2. *Toninia poeltii* (16-53317 KUN).
A. Thallus and apothecia; B. Epihymenium; C. Purple K reaction of epihymenium; D. Ascospores.

Toninia poeltii Timdal, Opera Bot. 110: 85 (1991) Fig. 2

Thallus squamulose, indeterminate. Squamules ≤1 mm diam. More or less continuous crust. Upper side dark greyish brown, epruinose, dull, with a few shallow fissures in the cortex, lacking pores and pseudocyphellae. Margin concolorous with upper side, epruinose. Upper cortex 30–80 µm thick, lacking crystals. Algal layer continuous. Medulla lacking crystals. Lower cortex ≤40 µm thick, brown pigment hyphae.

Apothecia ≤0.8 mm diam., plane and indistinctly marginate when young, later more or less convex and immarginate, epruinose. Proper exciple olivaceous green in the rim, colourless in inner part, K+ violet or brown, N–, lacking crystals. Hypothecium colourless. Hymenium 60–70 µm high;

epithecium olivaceous green, K+ violet or brown, N–. Spores bacilliform, often slightly curved, 1–3-septate, 12–21.5 × 4–5 µm.

Pycnidia not seen.

Chemistry—Terpenoids detected by TLC.

Specimens examined—**CHINA. Tibet**, **Mangkang**, on the way from Lawushan to the town of Rumei, alt. 4290 m, 20 Sep. 2016, Wang Lisong & al. 16-53317 (KUN); **Dingri County**, Alpine meadow, alt. 5250 m, 22 Aug. 2007, Wang Lisong & al. 07-28528 (KUN). **Yunnan**, **Deqin County**, Sola Mountain, 28°38.19′N 98°36.30′E, alt. 4800 m, 10 Sep. 2012, Niu Dongling & al. 12-35865 (KUN).

Distribution—On soil or rock. Reported only in the Himalayas (Timdal 1991). New to China.

Comments—The Chinese material closely matches the previously published description by Timdal (1991). *Toninia poeltii* is morphologically similar to *T. squalida* (which has not been recorded for China), but differs in having an olivaceous green, K+ violet/brown, N– pigment in the epithecium and exciple rim. *Toninia poeltii* has at most 3-septate spores, but *T. squalida* has 3–7-septate spores (Timdal 1991).

Toninia tristis* subsp. *arizonica Timdal, Opera Bot. 110: 112 (1991) Fig. 3

Thallus squamulose, squamules ≤6(–8) mm diam., scattered to adjacent, rounded, bullate but often with an irregular depression. Upper surface castaneous brown to dark brown, epruinose, dull, smooth in the cortex, lacking pseudocyphellae. Upper cortex ≤160 µm high, lacking crystals.

Apothecia ≤6 mm diam., plane and weakly convex, distinctly marginate, epruinose. Proper exciple brown to dark brown, colourless in inner part. Epithecium brown, partly with a green tinge. Spores simple, narrowly ellipsoid to fusiform, 8–17 × 4–4.5 µm. Orange pigment present in the upper part of the hypothecium and in the lumina of many paraphyses, asci, and spores; yellow pigment present in the upper part of the hypothecium.

Chemistry—Terpenoids and fatty acid detected by TLC.

Specimens examined—**CHINA**. **Inner Mongolia**, **Urad Rear Banner**, Huhe Bash GeTusheng, alt. 1600 m, 19 Aug. 2011, Tong Debao 20123675 (SDNU). **Ningxia**, **Jingyuan County**, Migang Mountain, alt., 2300 m, 20 Jun. 2011, Cheng Yuliang 20116001 (SDNU). **Sichuan**, **Ningnan County**, Baihetan Town, alt. 701 m, 18 Oct. 2013, Wang Lisong & al. 13-39450 (KUN); Jinsha River, alt. 1550 m, 20 Apr. 2014, Wang Lisong & al. 14-43367 (KUN). **Tibet**, **Naqu County**, 317 country road side slope, alt. 4680 m, 30 Sep. 2016, Wang Lisong & al. 16-51961 (KUN). **Yunnan**, **Yunmin County**, Jinsha River Valley, alt. 920 m, 27 Nov. 2014, Wang Lisong & al. 14-46464 (KUN); **Dongchuan**, Sandstone from Dongchuan to Qiaojia Road, alt. 1080 m 11 May 2017, Wang Lisong & al. 17-55053 (KUN).

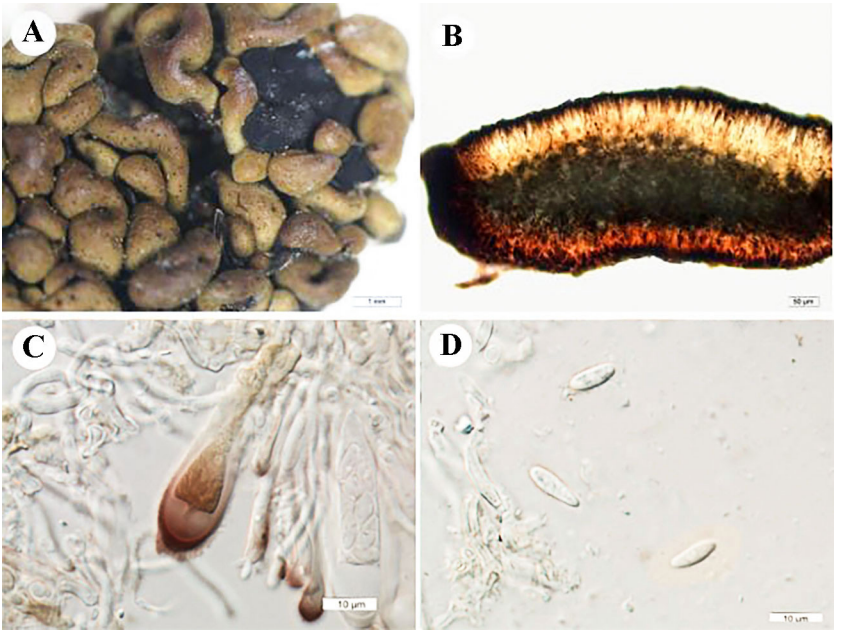

Fig. 3 *Toninia tristis* subsp. *arizonica* (16-53317 KUN).
A. Thallus; B. Epihymenium; C. Ascus; D. Ascospores.

Distribution—On soil. Arizona, USA (Timdal 1991). New to China.

Comments—The Chinese material closely matches the previously published description by Timdal (1991). *Toninia tristis* subsp. *arizonica* produces orange asci similar to *T. tristis* subsp. *asiae-centralis*, which differs in having 1-septate spores (Timdal 1991). In its possession of simple spores, the Chinese material closely matches previously published descriptions of *T. tristis* subsp. *pseudotabacina*, which differs in its absence of orange pigments (Timdal 1991).

Toninia tristis* subsp. *fujikawae (M. Satô) Timdal,
Opera Bot. 110: 113 (1991) Fig. 4

Thallus squamulose, squamules ≤4(–5) mm diam., continuous, bullate, often forming cushions. Upper side castaneous brown to dark brown, lacking pseudocyphellae. Margin concolorous with upper side, epruinose. Upper cortex not containing crystals. Algal layer continuous. Medulla

lacking crystals. Lower cortex resembling upper cortex, but stainable layer often dark reddish brown.

Apothecia ≤4 mm diam., plane and weakly convex, distinctly marginate, epruinose, Proper exciple brown to dark brown, colourless in inner part, K–, N–, lacking crystals. Hypothecium pale brown, 60–70 µm high; epithecium olivaceous green to bright green, K+ violet or brown, N–. Spores simple, ellipsoid, 7–12 × 3–5 µm. Orange and yellow pigments lacking.

Chemistry—Terpenoids and fatty acid detected by TLC.

Specimens examined—**CHINA**. **Sichuan**, **Huili County**, Jinsha River, alt. 1550 m, 20 Apr. 2014, Wang Lisong & al. 14-43349; 14-43368 (KUN); **Tibet**, **Wuqi County**, next to the 214 state road, 31°09′51″N 96°37′54″E, alt. 3840 m, 2 Oct. 2016, Wang Lisong & al. 16-51390 (KUN); **Baqing County**, Laxi village, 317 national road side slope, 31°50′17″N 94°23′24″E, alt. 4180 m, 1 Oct. 2016, Wang Lisong & al. 16-53934 (KUN). **Yunnan**, **Luquan County**, alt. 2540 m, 19 Apr. 2014, Wang Lisong & al. 14-43234 (KUN); **Deqin County**, Benzilan, 28°11′35.54″N 99°21′08″E, alt. 2112 m,19 Aug. 2018, Wang Chunxiao & al. 20180326 (SDNU).

Distribution—On rock or soil. Japan (Timdal 1991). New to China.

Comments—*Toninia tristis* subsp. *fujikawae* may be confused with *T. tristis* subsp. *canadensis* in having green epithecium, but the latter subspecies has mainly 1-septate ascospores (Timdal 1991). Although also characterized by simple spores, *T. tristis* subsp. *arizonica* is distinguished by a brown epithecium (Timdal 2002).

Key to the species of *Toninia* s.l. in China

Kistenich & al. (2018) place some species below in *Thalloidima* (*T. opuntioides, T. physaroides, T. sedifolia*) or other genera (e.g., *T. gobica*, *T. poeltii*). Here we follow Timdal (1991) and treat all species in *Toninia* s.l.

1. Thallus pruinose (farinose or granular) 2
1. Thallus epruinose to faintly pruinose 14
2. Epithecium gray, K+ violet, N+ violet 3
2. Epithecium brown, K+ red, or epithecium dark green to bright green, K–, N+ violet 13
3. Ascospores at least 1-septate 4
3. Ascospores 0–1-septate ..... *T. toniniana*
4. Ascospores mainly 3-septate 5
4. Ascospores exclusively 1-septate 6
5. Ascospores 1–3-septate, 13.5–22.5 × 3.5–5 µm ..... *T. superioris*
5. Ascospores mainly 3-septate, 23.5–33 × 3–4 µm ..... *T. alutacea*
6. Thallus pruinose, pruina farinose 7
6. Thallus pruinose, pruina granulate 10

7. Thallus rosulate, pruina exposed surface of thallus ..... *T. candida*
7. Thallus not rosulate, pruina patchy on thallus 8
8. Thallus with pseudocyphellae ..... *T. physaroides*
8. Thallus without pseudocyphellae 9
9. Squamules bullate and partly vertically flattened, more or less imbricate, containing an unknown substance (TLC solvent system C Rf. 21) ... *T. opuntioides*
9. Squamules weakly convex to bullate but not vertically flattened or imbricate; not containing an unknown substance (TLC solvent system C Rf. 21) ... *T. sedifolia*
10. Squamules margin usually densely with white pruina ..... *T. albilabra*
10. Pruina not only on the edge of squamules 11
11. Ascospores small (8.5–13 × 4–5 µm) ..... *T. nordlandica*
11. Ascospores larger (12–24 × 3–5 µm) 12
12. Thallus rosulate; apothecia ≤4 mm ..... *T. rosulata*
12. Thallus not rosulate; apothecia ≤1.5 mm ..... *T. diffracta*
13. Epithecium red-brown, K+ red ..... *T. lutosa*
13. Epithecium green, K–, N+ purple; ascospores 3-septate ..... *T. gobica*
14. Thallus epruinose or slightly pruinose 15
14. Thallus epruinose 17
15. Thallus pale brown; epithecium dark brown ..... *T. sculpturata*
15. Thallus of different colour; epithecium not dark brown 16
16. Thallus crustose; epithecium gray, K+ purple, N+ purple ..... *T. pennina*
16. Thallus squamulose, epithecium olive green to bright green, K–, N+ purple; ascospores 1–3-septate ..... *T. aromatica*
17. Epithecium olive green to bright green, K–, N+ purple 18
17. Epithecium red-brown, K+ red; ascospores (1–)7(–9) -septate ..... *T. ruginosa*
18. Thallus crustose; ascospores 1-septate ..... *T. philippea*
18. Thallus squamulose, or crustose to subsquamulose 19
19. Thallus crustose to subsquamulose; epithecium olive green; ascospores 3–7-septate ..... *T. coelestina*
19. Thallus squamulose; epithecium olive green to bright green 20
20. Ascospores simple to 1-septate; epithecium bright green to dark brown .. *T. tristis*
20. Ascospores 1 to more septate; epithecium olivaceous to bright green 21
21. Epithecium olivaceous to bright green (K–), ascospores 1(–3)-septate ..... *T. cinereovirens*
21. Epithecium olivaceous (K+ purple to brown), ascospores 1–(–3)-septate ... *T. poeltii*

Key to the subspecies of *Toninia tristis*

1. Ascus orange, K+ red 2
1. Ascus not orange, K– 3

2. Ascospores 1-septate ..... subsp. *asiae-centralis*
2. Ascospores simple ..... subsp. *arizonica*
3. Epithecium green 4
3. Epithecium brown 7
4. Ascospores 1-septate ..... subsp. *canadensis*
4. Ascospores simple 5
5. Ascospores larger (10–15.5 µm) ..... subsp. *pseudotabacina*
5. Ascospores small (8–12 µm) 6
6. No chemical substance ..... subsp. *thalloedaemiformis*
6. Containing chemical substance ..... subsp. *fujikawae*
7. Ascospores simple ..... subsp. *scholanderi*
7. Ascospores 1-septate 8
8. Squamules ≤2(–3) mm ..... subsp. *tristis*
8. Squamules ≤3(–4) mm ..... subsp. *coahuilae*

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